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NATIONAL PARK SERVICE
Cooperative Park Studies Unit
College of Forestry
Oregon State University
Corvallis, Oregon 97331

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Annual Report

National Park Service
Cooperative Park Studies Unit

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Terrestrial Ecology

Donald R. Field, Project Leader
Natural Resource Sociology

Gary Larson, Project Leader
Aquatic Biology

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Subagreement 2
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TABLE OF CONTENTS

	Page
INTRODUCTION	5
Terrestrial Ecology Program	6
Aquatic Biology Program	7
Natural Resource Sociology Program	8
PROJECT SUMMARIES: RESEARCH	13
PROJECT SUMMARIES: APPLICATION OF SCIENCE	42
PUBLICATION ACTIVITIES, 1986	47
CUMULATIVE LIST OF PUBLICATIONS, 1976-1985	49

INTRODUCTION

The National Park Service, Cooperative Park Studies Unit (CPSU) at OREGON STATE UNIVERSITY was established in 1975. This year marks the 11th anniversary of our cooperative agreement with the University. The purpose of the unit remains the same since its inception: (1) to conduct original research on topics of importance to the management of natural and cultural resources; (2) to encourage and facilitate scientific research in national parks in the Pacific Northwest Region; and (3) to disseminate research results within the management system of the National Park Service.

The NPS Cooperative Park Studies Unit is located in the College of Forestry, with the additional office space and laboratory facilities provided under a cooperative agreement with the Forestry Sciences Laboratory of the U.S. Forest Service's Pacific Northwest Forest and Range Experiment Station. In addition, a cooperative agreement signed between the National Park Service and the USFS provides opportunities for joint research and publication activities by the various research teams of the two federal agencies.

The staff of the CPSU is composed of three research scientists conducting research in wildlife, aquatic biology, and social science. The wildlife biology research program was initiated in 1975; in 1983, the sociology research program was established, and in 1984 an aquatic biology research program was initiated. These programs complement other such programs within the University and College of Forestry, as well as programs

in operation within the Pacific Northwest Science Program, though each science project is unique and is not duplicated within the University or NPS research organization.

Terrestrial Ecology Program

During 1986, the CPSU wildlife staff consisted of Ed Starkey, four Research Associates, and two graduate research assistants.

A major study of ungulate ecology in national parks of the Pacific Northwest was begun in 1985. The research includes Crater Lake, Olympic, and Mt. Rainier National Parks, and field work continued through 1986. A primary objective is the provision of improved baseline information on elk populations of these parks, with emphasis on census techniques, population dynamics, and movements and behavior. Potential influences of land management activities on adjacent nonpark lands are of special interest. A conceptual model of forest management impacts on national park elk will be developed in 1987. Ongoing research on nutritional ecology of cervids inhabiting old-growth forests also continued.

Two projects continued at Mt. Rainier National Park to assess the influence of elk on the park ecosystem. One will determine the effects of defoliation by elk on plant communities. Another study is evaluating the use of aerial photography to measure soil erosion and trampling impacts of elk. Both studies should provide important information for use in elk management planning.

During 1986, Starkey was involved, as a co-investigator, in a study to evaluate social and ecological impacts of recreation use on the Deschutes River. This study was commissioned by the Oregon Legislature.

Vegetation management alternatives were developed for several parks. In 1985, a plan was completed for Whitman Mission NHS, which included prescriptions for burning, mechanical and herbicide treatment, and seeding. Many of the recommendations were carried out in 1985, and seeding began in 1986. A primary concern is the control of exotic and noxious weeds, and re-establishment of native vegetation where feasible. A monitoring program will be developed in 1987.

Starkey served as chairman of the Interagency Subcommittee on Elk Management and Research. This subcommittee serves as a clearing house for agency supported elk research in the Northwest and provides technical assistance to land managers.

In June 1986, Starkey was co-director and instructor for a microcomputer workshop for resource managers. The course has been offered each summer through the College of Forestry, and is attended by individuals from various government agencies, timber companies, and consulting firms.

Aquatic Biology Program

Gary Larson's main responsibilities again centered on the Crater Lake limnological studies. A conceptual framework was completed and peer reviewed. The main emphasis will be on the interrelationships between the physical, chemical, and biological components of the lake system and their relationships to lake clarity. The monitoring program was refined and zooplankton and fish studies added. Sampling in March and May was possible because the research boats are now housed in a boat house on Wizard Island. The lake crew was helicoptered to the Island in March and lowered down the caldera wall by sled in May. Sampling during the normal season

(June - September) was completed as scheduled. The particle flux studies by Jack Dymond and Bob Collier continued. Studies initiated included the physics of the lake color by Peter Fontana and a detailed analysis of the dynamics of the phytoplankton community by Dave McIntire. Plans were also prepared for evaluating the relationships of climate and changing lake levels.

Larson assisted Mount Rainier in preparing a water resources management plan and initial water sampling of park streams. He also assisted Olympic National Park develop the initial plans for a high lake study. Work plans were also prepared for a review of the literature and park lake and fish data for a evaluation of fish stocking at North Cascades National Park Complex. Larson also reviewed the Coulee Dam National Recreation Area resource management plan.

Larson is a member of the WASO Museum Collections Committee and the Technical Coordinating Group on Atmospheric Pollution in Park Ecosystems. He is the National Park Service representative on the aquatic effects group of the National Acidic Precipitation Assessment Program.

Larson has courtesy appointments in the College of Forestry, Department of Fisheries and Wildlife, and General Science Department at Oregon State University.

Natural Resource Sociology Program

The 1986 calendar year represented the third full year of operation for the natural resource sociology studies program. The establishment of a research and extension program for clients in the Pacific Northwest and Western Regions was completed and services on a contract basis undertaken.

Emphasis in the research program during 1986 was placed on four projects: (1) the Whiskeytown visitor survey, (2) the Three-state Recreation Demand Study, (3) Visitor pulses conducted at Ft. Vancouver and Ft. Clatsop, and (4) "initiation of a park and its region" problem analysis.

The Whiskeytown visitor survey was begun during 1985. After completion of a questionnaire and sampling plan in the spring of 1985, data collection began on Memorial Day 1985 and continued until Labor Day 1985. Approximately 3200 interviews were conducted and a similar number of questionnaires distributed. A seventy-five percent response rate was recorded from the questionnaires for the entire summer. Data entry was completed in the fall of 1985 and analysis begun in 1986. Three reports have been completed at this time. The first reviewed the literature on water-based recreation. This reference guide will allow the park staff to orient employees and future scientists to research problems and issues associated with water-oriented recreation. The second report describes the major recreation habitats comprising Whiskeytown. This inventory provides descriptions of the social, managerial, and biological dimensions of those settings where people recreate. The third report describes the visitors to Whiskeytown during the summer of 1985. Future reports will include discussions of perceptions of crowding and carrying capacity, views on interpretation and visitor perception of management problems.

A research proposal was prepared during the year in cooperation with Dr. Perry Brown, Head, Department of Resource Recreation Management to study the recreation participation of Oregonians and their use of national parks. The study is funded jointly by Oregon State Parks and NPS and is

part of a three-state, Washington, Oregon, and Idaho, recreation inventory. This 1986-87 Pacific Northwest Outdoor Recreation Study is a coordinated regional approach to gathering recreation demand data central to the SCORP process. A first for the region, the study will provide current recreation use data and future recreation demand projections not only for the states of Oregon, Washington, and Idaho but also for the Northwest as a geographic region. Close coordination among participating state and federal agencies during questionnaire and sample design has ensured the compatibility and comprehensiveness of data for regional modeling of recreation demand. We are currently conducting a twelve-month survey to gather the data requested. In addition, our staff is assisting the states of Washington and Idaho in the conduct of their complimentary studies.

Another study emphasis concerns resource dependent communities (forestry, agriculture, and mining). The project is being conducted jointly with cooperating universities. The information obtained provides an improved understanding of resource demands on ecosystems adjacent to parks and potential effects upon park resource systems. In addition, an initiative was presented in 1982 (Regional Director's number one priority) to fund a program of research on parks and their regions with the Puget Sound as a trial area. National parks are tied socially, economically and ecologically to the biophysical region of which they are a part. Change in the regional ecological system has in interaction effect upon national parks. The monitoring of human activity outside a park offers opportunity to understand potential changes (anticipatory planning) in the environment

prior to actual alteration to park resource systems. The OSU/CPSU has a work program initiative to conduct a literature review and problem analysis in this area.

Finally, changes in population structure, and trends in leisure demand require park management to undertake periodic assessments of the visitor population to their area. Our staff conducted two visitor pulses on consecutive August weekends at Ft. Vancouver National Historic Park and Ft. Clatsop National Memorial. These weekend surveys provide a picture of the nature of the clientele, their impressions of interpretation at the specific area, and travel plans while visiting the NPS site.

The development of an extension program for the dissemination of scientific information through short courses, symposiums, and appropriate management reports was completed. Two short courses were conducted. The first, a workshop on microcomputers for resource managers, was coordinated by Marty Lee. The hands-on workshop, held in June, included fifteen participants representing various public and private land management agencies. In November, a new short course entitled "People, Parks, and Forest" was offered. There were thirty attendees, including NPS and USFS rangers and Oregon State Parks, wildlife and forestry professionals attended. Subjects discussed included a framework to assess recreation opportunities, carrying capacity, nonmarket evaluation and interpretation.

The first National Symposium on Social Science and Resource Management was held at Oregon State University in May of 1986. Over 280 professionals attended the five-day symposium. Over 150 presentations were made representing such topics as social policies associated with resource

management, human behavior and wildlife recreation, forest communities in transition, resident populations and parks, and science in resource management agencies.

Don Field was a member of an evaluation team to assess management operations at Mt. Rainier National Park. Kris Martinson and Don Field completed the evaluation study of Park Science and an article summarizing the findings appears in Park Science Vol. 7, No. 1 (Fall 1986). Don Field prepared several short reports for the Regional Director, Pacific Northwest Region on such subjects as social trends potentially effecting parks, a publications inventory and productivity enhancement program. Field also taught at an interpretation short course at Mather Training Center and at a safety managers workshop at Albright Training Center.

Editorship responsibilities and participation in professional development continued in 1986. Field completed another year as editor of Leisure Science. Four issues were prepared and distributed in 1986. He likewise attended the annual meetings of the Rural Sociological Society in Salt Lake City, Utah.

PROJECT SUMMARIES:

RESEARCH

SOCIAL AND ECOLOGICAL IMPACTS OF RECREATIONAL USE
ON THE DESCHUTES RIVER

Co-investigators: Bo Shelby
Douglas Whittaker
Department of Resource Recreation
Management
Oregon State University

Bob Speaker
Ed Starkey
Cooperative Park Studies Unit
Oregon State University

Objectives: Identify social and ecological impacts of recreation use, assess existing resource condition, establish standards for acceptable use levels and impacts, and identify management strategies to limit impacts.

Progress: Field work was completed during the summer of 1986. The primary contribution of the CPSU was the assessment of existing conditions for the natural resources along the river and the development of standards of acceptable impacts. The general area has been heavily disturbed by road and railroad construction, as well as by livestock grazing. Thus, an important task was the identification of those impacts caused by recreational use, rather than other human activities.

This information will be combined with user survey data to provide the basis for a final report to the Oregon Legislature to be completed in early 1987.

INFLUENCE OF ADJACENT LAND-USE PRACTICES ON ELK
OF PACIFIC NORTHWEST NATIONAL PARKS

Principal Investigator: Edward E. Starkey
Cooperative Park Studies Unit
Oregon State University

Research Associate: Kurt J. Jenkins
Cooperative Park Studies Unit
Oregon State University

Objectives: The goal of this study is to determine the effects of forest management practices occurring outside National Park boundaries on the long-term carrying capacity of elk populations in National Parks of the Pacific Northwest. Specific objectives are as follows:

- 1) To critically review carrying capacity models that are used to evaluate the environmental effects of forest management practices on elk populations.
- 2) To review existing information relating to elk ecology on lands adjoining northwestern national parks to derive data pertinent to the estimation of carrying capacities; and
- 3) To develop a conceptual model of forest management impacts on national park elk.

Progress: This research will emphasize elk and range relationships in Mount Rainier National Park and vicinity, but has applications to Olympic National Park and Crater Lake National Park as well.

Information has been collected on models currently in use for estimating elk carrying capacity and habitat effectiveness. Four broad classes of models are in use by federal and state land management agencies or university personnel for estimating the effects of forest management practices on elk range quality. Models reviewed to date include the following:

- 1) Carrying capacity models based on acreages of habitat components and the estimated densities of elk in each,
- 2) Carrying capacity models based on appraisals of forage quality or quantity and daily nutrient requirements of elk,

- 3) Habitat effectiveness models based on estimates of elk habitat quality as a function of cover to forage area ratios, road densities, and other habitat qualities,
- 4) Probabilistic models that predict population densities of elk as functions of habitat qualities.

In the current ongoing effort, characteristics, purposes, and inherent assumptions of those modeling approaches are in review. Following this review, a conceptual model will be developed describing the relationships of forest management to elk populations in Mount Rainier National Park. Field work was conducted during 1986 to provide data for use in this model. Of primary concern is relative abundance of various forage species on elk winter ranges.

FORAGE QUALITY IN OLD GROWTH FORESTS

Co-principal Investigators: Edward Starkey
Cooperative Park Studies Unit
Oregon State University

Steven Sharrow
Dept. of Rangeland Resources
Oregon State University

Research Associate: Patricia J. Happe
Cooperative Park Studies Unit
Oregon State University

Objectives: Research was initiated on the quality of ungulate forage in old growth forests in Olympic National Park, and the influence of ungulate herbivory on forage quality. Pursuant to these goals, three general research objectives were identified: 1) to compare the quality of key browse species in and outside of elk exclosures; 2) to examine the effect of artificial browsing on protected plants within exclosures; 3) to compare forage quality in old growth forests and early seral clearcuts.

Progress: Over 240 samples of current annual growth were gathered from sites in and adjacent to Olympic National Park. Samples were taken from two exclosures located in the South Fork of the Hoh and one in the Elwah drainage. Three replicate samples of salmonberry, red huckleberry, swordfern, and vine maple were taken from both in and out of the exclosures. Additionally, a single sample of wood sorrel, deer fern, and youth-on-age were taken from in and outside of the exclosures for descriptive purposes. Not all species were available in all exclosures. Samples from inside the exclosures consist of composite of 50% of the current annual growth of plants selected randomly along transects. All sampled plants were marked and resampled in July 1986 to examine the effect of artificial "browsing" on protected plants.

Samples of salmonberry, red huckleberry, swordfern, and vine maple were gathered in four early seral clearcuts. The clearcuts were located on river terraces, two on each side of the Hoh, with site location ranging from adjacent to the park to 1.5 miles from Highway 101. These samples will be compared to plant samples of the same species gathered in four blocks located within old growth forests inside the park. Samples of ten additional forage species were also gathered. Finally, samples of vine maple, salmonberry, swordfern, and red huckleberry were gathered from four blocks located in elk winter ranges in Dosewallops drainage.

Laboratory analyses are currently in progress; however, the following analyses will be performed: percent dry matter, crude protein, neutral

detergent fiber, acid detergent fiber, lignin, in vitro digestibility,
macro and micro minerals, leaf area, and condensed and hydrolyzable tannins.

MOVEMENT, HOME RANGE, AND HABITAT USE OF MIGRATORY
ROOSEVELT ELK IN OLYMPIC NATIONAL PARK

Principal Investigator: Edward Starkey
Cooperative Park Studies Unit
Oregon State University

Research Assistant: Gregory Schroer
Dept. of Fisheries and Wildlife
Oregon State University

Objectives: This study was initiated in the Duckabush and Dosewallips valleys of the Olympic Peninsula to obtain information on annual movements, home range, and habitat use of migratory Roosevelt elk. The second goal is to investigate land use impacts on elk that migrate from Olympic National Park. The study has the following specific objectives:

1. Determine the seasonal home range boundaries and migratory movements of the Duckabush and Dosewallips elk.
2. Determine what habitats are utilized by the elk and the relative preference and avoidance of those habitats.
3. Determine how human activities, such as motor vehicle traffic and hunting, and developments, such as rural residences, subdivisions, and roads, influence the spatial and temporal distribution of elk.

Progress: Field studies were completed on December 15, 1985, and the final report completed in December 1986. Areas of concentrated activity within winter and spring home ranges are on the valley floors and lower portions of the valley slopes. These areas also contain the greatest amount of residential development and human activity. Elk using areas with the greatest human disturbance have developed nocturnal habits that minimize contact with humans. Use of residential areas and areas near roads with the highest vehicle traffic was limited to late night and early morning hours.

Hunting pressure along the park boundary and at lower elevations increases the minimum daily movements as compared with movements of all other seasons. Areas of concentrated activity within the summer, and rutting home ranges were dispersed among preferred foraging areas that are isolated by steep, rocky ridges.

During the 31 to 50 day spring and autumn migrations, elk showed a preference for areas containing an abundance of herbaceous and shrub vegetation. These areas included valley bottoms with a deciduous forest canopy and avalanche paths dominated by shrubs.

ECOLOGY OF ELK INHABITING CRATER LAKE
NATIONAL PARK AND VICINITY

Principal Investigator: Edward E. Starkey
Cooperative Park Studies Unit
Oregon State University

Research Associates: Kevin Cooper
Cooperative Park Studies Unit
Oregon State University

- Objectives:
1. Describe seasonal movements, migration routes, and home ranges of elk inhabiting Crater lake and the immediate vicinity.
 2. Determine habitat use patterns.
 3. Determine herd sizes and composition, where possible.
 4. Evaluate the influence of adjacent land use practices on elk of Crater Lake National Park.

Progress: Crater Lake National Park provides summer range for elk, but the winter range is located at lower elevation outside the park boundaries. Thus, the study has been a cooperative project with the Oregon Department of Fish and Wildlife, U.S. Forest Service, and Klamath Indian Tribe.

Eleven cow elk were captured and radio-collared between April 30 and June 12, 1985. Elk were captured in traps located near the south boundary of the park, on the Winema National Forest. One of the collars failed in early June.

These elk generally occupied the southern portion of the park during the summer. Elk were widely dispersed and were not found in large groups, most were observed in groups of 5-10 individuals.

Following heavy winter snows in late October and early November elk generally move to winter ranges southwest of the park in the mouth of Red Blanket Canyon. This winter range has been heavily influenced by logging and livestock grazing.

Elk movements were monitored through October 1986. A final report will be completed in spring 1987.

REMOTE SENSING OF ELK TRAIL AND WALLOW IMPACTS
IN MOUNT RAINIER NATIONAL PARK

Principal Investigators: William J. Ripple
Barry J. Schrumph
Environmental Remote Sensing
Applications Laboratory (ERSAL)
Oregon State University

Ed Starkey
Cooperative Parks Studies Unit
Oregon State University

Progress: There is concern that the apparent population growth of Mount Rainier's north elk herd may be subjecting several Park ecosystems to overuse, damage, and substantial alteration. The purpose of this project is to develop a system to inventory and monitor trails and wallows caused by elk in the northeastern part of Mount Rainier National Park. One objective of this project is to determine if elk trail and wallow impacts to vegetation and soils can be documented using remote sensing and other analytical techniques. The task of establishing an inventory and monitoring system was started in August 1985. Two approaches have been initiated: 1) complete enumeration of elk trails conducted in the field for forested areas with the aid of topographic maps and resource aerial photographs; and 2) mapping of trails and wallows in nonforested areas from large scale aerial photographs conducted in the laboratory and field checked for accuracy.

Large scale aerial photography has proven useful for monitoring impacts. Further development and testing will continue in 1987.

BIOACCUMULATION OF METALS IN MOUNTAIN GOATS IN
MOUNT RAINIER, OLYMPIC, AND NORTH CASCADES
NATIONAL PARKS, WASHINGTON

Principal Investigator: Edward E. Starkey
Cooperative Park Studies Unit
Oregon State University

Research Associate: Richard W. Frenzel
Dept. of Resource Recreation
Management
Oregon State University

- Objectives:
1. Determining existing concentrations of arsenic and other metals in hair of mountain goats in Washington State's national parks to provide a measure for changes in airborne metal contamination from potential pollutant sources.
 2. Compare relative contamination of the three parks with proximity to pollutant sources.
 3. Determine bioaccumulation and trophic level transference of selected metals from vegetation to mountain goats.

Progress: During summer 1985, over 200 samples of Mt. goat fur were obtained from fifteen sites in Mt. Rainier, North Cascades, and Mt. Rainier National Parks. Samples were collected from live animals during capture and transplant operations at Olympic National Park, as well as from shrubs, rocks, and the ground surface at bedding areas in all three parks.

Fur was combed and cleaned to remove coarse debris, and washed and double-rinsed with deionized water to remove external contamination. It was then digested with perchloric acid and analyzed by atomic absorption for lead and arsenic content. Precautions were taken to reduce volatilization of arsenic.

Although there was considerable variation among sites, concentrations of both arsenic and lead were highest for North Cascades National Park, intermediate for Olympic National Park, and lowest for Mt. Rainier National Park. Statistical analyses suggest that arsenic and lead concentrations were influenced by distance from the ASARCO Smelter and annual precipitation. However, the most important variable was the relative direction from the ASARCO site, especially for arsenic. Principal components analysis revealed that concentrations decreased rapidly with departure from a north-northeast vector from Tacoma, which was somewhat

less influenced by direction, probably because the emission sources are relatively more dispersed than for arsenic.

Although there are no studies from elsewhere with which to compare these results, heavy metal concentrations in goat fur do not suggest that an acute problem of environmental contamination exists. However, North Cascades National Park appears to be especially vulnerable to air pollution from the Seattle-Tacoma metropolitan area and further studies should be undertaken to document baseline levels of environmental contaminants. In addition, Olympic National Park is apparently fairly vulnerable to contamination by arsenic from the Tacoma area. This may no longer be a potential problem because the smelter has been closed.

REVEGETATION WITH NATIVE PLANT SPECIES
ON THE JOHN DAY FOSSIL BEDS NATIONAL
MONUMENT

Principal Investigators: M.R. Haferkamp
R.F. Miller
Eastern Oregon Agricultural
Research Center
Oregon State University

- Objectives:
1. To re-establish native vegetation in selected areas of John Day Fossil Beds National Monument.
 2. Develop and test methodologies for use in similar areas of the Pacific Northwest.

Three areas within the John Day Fossil Beds National Monument were selected for study in 1984. Seedbeds for 1986 plantings on the upper Foree site, a deteriorated Artemisia tridentata-agropyron spicatum community, were prepared by either burning on June 4, 1985, or burning in June 1985 followed by spraying with 1 pound active ingredient glyphosate per acre on March 26, 1986. Secar blue bunch wheatgrass was planted on March 28 and October 15, 1986, with a rangeland drill at a rate of 15 pure live seeds per square foot. One-half of each 30x40 foot plot was mulched with straw immediately following planting at 400 pounds per acre. Treatments are arranged in a split-block design with seedbed preparation as major plots, season of planting as subplots, and mulching as sub-subplots. Treatments are replicated four times. Treatment effects on soil moisture and seedling establishment were monitored periodically during spring and summer 1986 and will be monitored in 1987. In the spring planting, seedlings did not emerge until after May 21 when 0.9 inch of rain was received. On June 6, seedling density was 0.8 and 0.4 plants per square foot on the mulched and no mulched burn spray treatments and less than 0.1 plants per square foot on the burn treatments. Only the mulched burn spray treatment produced a successful seeding by June 6; however, the seedlings were small and success of the planting will be determined in spring 1987. During June and July soil moisture continued to decrease even though 0.6 inch of rainfall was received. The rainfall occurred as showers of less than 0.2 inch. The burn spray seedbed preparation treatment significantly reduced weed competition. Weed canopy cover was 9.5 and 28.8 % and weed dry weight was 62 and 356 pounds per acre for the burn spray and burn treatment, respectively. By December 22, 1986 some seedlings had emerged in the fall planting.

The Sheeprock site, a deteriorated Artemisia tridentata-Agropyron spicatum community, was disced on April 30, 1985, and again on June 4, 1985. Secar bluebunch wheatgrass was planted November 1985, at 20, 40, and 60 pure live

seeds per square foot and T2950 bluebunch wheatgrass, an experimental strain, supplied by the USDA, Soil conservation Service, Aberdeen Plant Materials Center, was planted at 20 pure live seeds per square foot. Seedling density was determined on April 8, 1986 when seedling development ranged from the 2 to the 5 leaf stage. Densities were 3.0, 5.0, 9.2, and 2.6 seedlings per square foot for 20, 40, and 60 Secar and 20 T2950 treatments, respectively. These densities indicate the seeding was very successful for all treatments. The weedy competition density was 10.2 plants per square foot and was composed mainly of bur buttercup (Ranunculus testiculatus), wallflower mustard (Erysimum repandum), jim hill tumble mustard (Sisymbrium altissimum) and blue mustard (Chorispora tenella). Weed canopy cover was 69.3% on May 5 and increased to 85.5% by June 16, when weed dry weight was 4600 pounds per acre. By June most of the weedy species were drying, while the bluebunch wheatgrass was flowering. Soil moisture decreased from 27.2% in February to 10.0% in June and continued to decrease to 9.5% in July. First year data analysis has been completed.

The Lower Foree site (3.5 acres), deferred in 1984 due to dense stands of quackgrass (Agropyron repens), was sprayed with glyphosate at 2 pounds active ingredient per acre on June 13 and burned on September 24, 1985 to remove the plant residue. Small areas of resprouting quackgrass were sprayed with glyphosate from a hand operated backpack sprayer on April 8, 1986. Plots were disced on June 6, 1986 to kill annual forbs and grasses before they produced seed. Plots were planted on October 7 and 8, 1986 with Magnar basis wildrye (Elymus cinereus) broadcast at 20, 40, and 60 pure live seeds per square foot before imprinting. No seedlings had emerged by December 22, 1986.

The abandoned field at Foree burned on September 14, 1985, had several small areas where quackgrass was vigorously growing. These areas were sprayed on April 8, 1986 with glyphosate from a hand-operated backpack sprayer. On June 6, 1986 the area was disced to kill annual forbs and grasses before they produced seed. The area was planted on October 14, 1986 to Secar and T2950 bluebunch wheatgrass with the same design and treatments as the Sheepprock area. Some seedling emergence had occurred by December 22, 1986.

Poor establishment of bluebunch wheatgrass (Agropyron spicatum) appears to be related to seed size and early seedling development. Commercial Secar bluebunch wheatgrass separated into heavy and light components, foundation Secar, and T2950, an experimental selection, were grown in individual tubes in high and low light during the summer or fall 1985. Entire plants were harvested at the 2, 3, and 4-leaf stage. Leaf length and area, root number and length, and dry weight for each compartment were recorded. During the study, survival rate ranged from 99% for heavy commercial Secar in low light to 80% for light commercial Secar in full light. The seminal root system generally consisted of three fine highly branched roots. Larger sparsely branched nodal roots first occurred in the 2-leaf stage, and by the 4-leaf stage 90% of the plants had developed nodal roots. Tillering first occurred in the 3-leaf stage in high light and in the 4-leaf stage in

low light. By the last harvest, 75% of the plants had tillered. The development of each source followed the same patterns, however, seedling size varied between sources. The largest seedlings were T2950 followed by foundation and heavy Secar, while light Secar were the smallest. Analysis of this data is continuing.

PLANT RESPONSE TO ELK-GRAZING IN ALPINE MEADOW
COMMUNITIES ON MOUNT RAINIER

Principal Investigator: Steven H. Sharrow, Dept. of
Rangeland Resources
Oregon State University

Research Assistant: David Kuntz, Dept. of Rangeland
Resources
Oregon State University

Objectives: This study is designed to provide basic biological information in support of an ongoing elk monitoring effort at Mount Rainier National Park. Specific objectives include (1) to estimate the degree of forage utilization by elk which is occurring on three subalpine meadows within the park, and (2) to determine the effects of season and intensity of defoliation on dry-fescue type subalpine plant communities. Results of this study are meant to aid in the management of these subalpine plant communities by quantifying the amount of plant defoliation of elk which is taking place, by estimating the amount of grazing which can be sustained without damage to the plant community, and by identifying plant indicators of overgrazing.

Progress: Activities this year focused on data collection and analysis. A small weather station was established at Yakima Park to record air temperature, relative humidity, rainfall, and soil temperature. Defoliation treatments consisting of different combinations of season (early, mid, and late growing season) and intensity (0, 25, 50, or 75% of standing biomass removed) of clipping were applied to plots protected from elk grazing by an electric fence in Yakima Park. Percent canopy cover of all plots was measured in July prior to application of any treatments. Plant biomass, frequency and the number of green fescue seedheads were determined at the end of the growing season. These data are meant to provide a measure of plant growth and asexual reproduction responses to defoliation treatments. The amount of grazing use and the specific plants grazed by elk were surveyed on Yakima, Bear, and White River Parks to provide information relating our defoliation treatments to the actual amount of elk grazing which is occurring on these dry subalpine meadows.

Analysis of 1986 field data is not yet complete. However, visual assessment of plots suggest that green fescue, a major elk forage species, flowers early in the growing season. Defoliation of almost any kind appears to effectively prevent seed production of green fescue during the remainder of that year.

Field work in 1987 will largely be the same as that conducted in 1986. Data collected in 1986 will be analyzed and summarized prior to the beginning of the 1987 field season in July.

CRATER LAKE LIMNOLOGICAL STUDIES

Principal Investigator: Gary L. Larson
Cooperative Park Studies Unit
Oregon State University

Collaborators: John Jarvis, Jim Milestone and
Jerry McCrea
Crater Lake National Park

Elena Karnaugh and Mark Buktenica
Department of Fisheries and
Wildlife
Oregon State University

Objectives:

1. Develop a detailed baseline data set of the general limnological characteristics of the lake that will serve as a benchmark for future studies.
2. Develop an understanding of lake organization and structure.
3. Establish a long-term limnological monitoring program.

Progress: The FY 1986 field season included sampling in March and May through September. The "off season" sampling was possible because the research boats are now housed in a boathouse on Wizard Island. The lake crew was helicoptered on to the island in March and lowered by sled down the caldera wall in May. From June through September the lake was accessible by the Cleetwood trail. Baseline data included general physical and chemical features, plus chlorophyll, phytoplankton, zooplankton and fish. Primary production was estimated in August (an estimate was not possible in September because of rough lake conditions). The particle sedimentation study continued and several sediment cores were collected. Work began on lake color which is a repeat of a Crater Lake study conducted in 1935. Planning was completed for a study of the nutrients in snow and rain and a study of the relationships between climate and the level (elevation) of the lake. A storage rain/snow gauge was installed on the southwest edge of the caldera rim.

Plans for the next year include: (1) continuation of the monitoring program; (2) completion of the analysis of the 1986 zooplankton samples; (3) continuation of the lake color experiments; (4) extensive evaluation of lake turbidity using a transmissometer; and (5) an evaluation of the relationships between climate and changing lake levels.

PHYTOPLANKTON TAXONOMY AND ECOLOGY OF CRATER LAKE

Principal Investigator: C. David McIntire, Professor
Department of Botany and Plant
Pathology
Oregon State University

Co-investigators: Mary DeBacon
Department of Botany and Plant
Pathology
Oregon State University

Gary L. Larson
Cooperative Park Studies Unit
Oregon State University

Objectives:

1. To perform a statistical analysis of the 1980-84 phytoplankton data sets.
2. To provide recommendations for sampling phytoplankton.
3. To examine and quantitatively analyze the phytoplankton samples obtained during the period from summer 1985 through summer 1986.

Progress: Objectives (1) and (2) were completed relative to the design of the FY 1986 monitoring program. Additional evaluations will be done in the near future to complete our assessment of the structure and dynamics of the phytoplankton community. The samples from 1985 and the 1986 samples through July have been processed and computerized.

Plans for next year include (1) finishing the quantitative analysis of the data; (2) processing of the remaining 1986 samples; and (3) interpreting patterns in the phytoplankton during 1985 and 1986 relative to the available physical, chemical, and biological data supplied by other scientists working at the lake.

MAJOR ION, ACID-BASE AND DISSOLVED ALUMINUM CHEMISTRY OF
SELECTED LAKES IN MOUNT RAINIER NATIONAL PARK

Principal Investigator: Peter O. Nelson
Department of Civil Engineering
Oregon State University

Co-investigators: Bob Baumgartner
Department of Civil Engineering
Oregon State University

Gary L. Larson
Cooperative Park Studies Unit
Oregon State University

Objectives:

1. Characterize the major ion and aluminum chemistry of the lakes.
2. Document seasonal variability of the lake water chemistry.
3. Determine the sensitivity or extent of acidification of the lakes with respect to major ion and aluminum chemistry.

Progress: Sixteen lakes in Mount Rainier National Park were evaluated between July and September 1985 to determine the extent and sensitivity of the lakes to acidification. Water samples were analyzed for total dissolved, labile, and nonlabile aluminum, major anions, major cations, dissolved silica, dissolved organic carbon, and pH.

The lakes are highly sensitive to acidification, but acidification, if present, is below the detection limits of the methods used. Concentrations of aluminum follow theoretical predictions and appear to be controlled by an aluminum trihydroxide solid phase similar to natural gibbsite. Seasonal variation of aluminum was observed in some lakes from organic complexes responding to changing concentrations of dissolved organic carbon.

Plans for next year include the preparation of a manuscript for publication in a peer-reviewed scientific journal.

GEOCHEMISTRY AND LIMNOLOGY OF CRATER LAKE

Principal Investigators: Robert Collier
College of Oceanography
Oregon State University

Jack Dymond
College of Oceanography
Oregon State University

Objective: Document the geochemical cycles of a variety of elements in Crater Lake by characterizing their concentrations and fluxes.

Progress: A major field component of the study involves the collection of settling particles with sediment traps and their accumulation at the lake bottom with sediment cores. Another research component involves the determination of dissolved trace metal concentrations in several verticle profiles and horizontal transects of the lake and in some of the major spring inputs along the sough wall of the caldera. We hope to develop a quantitative model for the fluxes of major and minor elements through the lake basin to help address questions of the significance of hydrothermal circulation in the lake, the nutrition of lake phytoplankton, and the significance of anthropogenic perturbations.

Sedimentation traps have been deployed in the lake since the summer of 1983 and sediment cores were taken in 1985 and 1986. Although the data are still being analyzed, we can make some estimates of the rates of nutrient and metal cycling in the lake. For instance: greater than 90% of the total primary production is recycled within the euphotic zone; greater than 60% of the organic matter that settles out the euphotic zone is recycled before it reaches the lake bottom; and greater than 80% of the organic carbon and nitrogen that reach the lake bottom are recycled before final burial in the sediments.

The presence of hydrothermal inputs to the deep lake was conclusively documented based on the discovery of a helium isotope anomaly. The laboratory work was performed by J. Lupton of the University of California, Santa Barbara.

Plans for the next year include (1) recovery of sediment traps now in the lake; (2) complete the initial analysis of the data; (3) development of the quantitative model; (4) assisting with the deployment of the NPS transmissometer and analysis of the data; and (5) preparation reports and manuscripts for publication in peer reviewed scientific journals.

A STUDY OF SELECTED ECOSYSTEM PARAMETERS POTENTIALLY
SENSITIVE TO AIRBORNE POLLUTANTS

Investigators:

Gail Baker and Mark Harmon
Oregon State University

Sarah Greene and Jerry Franklin
U.S. Forest Service

G. Bruce Wiersma
EG & G Idaho, Inc.

Objectives: To establish rates of ecosystem processes in a near pollutant-free environment and measure yearly patterns of variability of these processes. The methodologies used in this study range from standard to untested designs. All procedures are being tested and scrutinized. Our goal is to make suggestions about the kinds of processes and procedures to measure and use for accurate baseline data collection.

Progress: The processes or parameters under study are important contributors to long-term ecosystem productivity and nutrient cycling. They include lichen productivity, moss productivity, litter decay, litter fall and needle retention.

The study was initiated during the spring of 1984 when a research site was located and a permanent 1 ha plot established. The plot was characterized as to species and number of trees 15 cm dbh, downed trees, moss flora composition and standing crop. During the summer standard litter traps were randomly placed throughout the stand and monthly sample collection commenced. Throughout the following twelve months experiments to measure and monitor the remaining parameters were established.

Currently over two years of litter fall data has been analyzed. The results are indicative of litter fall patterns for ten components (cones, needles, etc.). Nutrient, lignin and trace element composition have been analyzed for the needle component. The period of greatest needle fall corresponds to the onset of the summer dry period. Litter decay, measured using a standard litter bag technique, is in its third year. During 1983 a preliminary experiment was done to determine decay rates of a variety of species. Ten species with different initial lignin and nitrogen contents are being studied. Decay rates of material leached before placement in the field is much slower than unleached material. A major goal is to determine differences between physical and biological decay processes and the relationship to the composition of the leaf and needle tissue. A study of Picea sitchensis and Isuga heterophylla needle populations suggest that both species begin to lose needles in significant numbers after three years and have lost approximately 60% of their needles from six-year-old branches. However, the total length of needle retention in P. sitchensis appears to be a year or two longer than for I. heterophylla.

Measuring lichen and moss productivity required several trials and modifications before a workable design was found. Lichen thalli are weighed at three-month intervals to determine any biomass changes. There has been a 50% biomass increase between March and September for these samples. This is approximately 20 to 30% higher than growth measured in the Oregon Cascades and Coast Range using a similar technique. Monthly moss phenology measurements show bimodal growth patterns for the dominant moss species, Hylocomium splendens. Annual productivity of this species is between 20 and 25%. Data suggests that biomass may fluctuate seasonally.

There are simultaneous chemical analyses of the biological tissue under study and monitoring of atmosphere composition and stream chemistry in the watershed. Climatic patterns are also considered in order to present a comprehensive picture of the interactions between biological processes and their environment.

Two manuscripts detailing the moss productivity studies are in preparation.

A BASELINE VEGETATION SURVEY OF THE HOH AND DOSEWALLIPS
DRAINAGES, OLYMPIC NATIONAL PARK, WASHINGTON

Investigators:

Jan Henderson
U.S. Forest Service

Brad Smith
Oregon State University

Objectives: Prepare a baseline survey of the vegetation of the Hoh and Dosewallips drainages, including both flora and plant communities. Relate landscape vegetation patterns to major topo=environmental factors.

Progress: A total of forty-eight treeland, twenty shrubland, and twenty-five herbland communities have been described for five zones: alpine, subalpine, upper montane, lower montane, and coastal. Temperature and moisture regimes determine inter- and intra-zonal patterns. While both drainages share a similar flora, the communities found within each drainage show little overlap. The final report is complete.

SCIENTIFIC INFORMATION BASE FOR OLYMPIC, MT. RAINIER
AND NORTH CASCADES NATIONAL PARKS

Investigators: Jerry F. Franklin
 U.S. Forest Service

 Dean W. Taylor
 Oregon State University

Objectives: To characterize existing data bases and scientific activities for Olympic, Mt. Rainier, and North Cascades National Parks. To assess the existing scientific facilities at these parks. To assess data analyses capabilities at these three parks.

Progress: The Olympic National Park report has been submitted as a final report. The Mount Rainier National Park report is ready for peer review. The North Cascades National Park report is in the process of being prepared; the bibliography has been completed and is ready for review.

RECREATION PATTERNS AT WHISKEYTOWN: ESTABLISHING SOCIAL
INDICATORS FOR MEASURING CARRYING CAPACITY

Principal Investigators: Donald R. Field
NPS Cooperative Park Studies Unit
Oregon State University

Marty Lee
Dept. of Resource Recreation
Management
Oregon State University

Bo Shelby
Dept. of Resource Recreation
Management
Oregon State University

- Objectives:
1. Provide managers of the Whiskeytown Unit of the Whiskeytown-Shasta-Trinity National Recreation Area with a picture of current recreation use patterns on the reservoir.
 2. Describe areas of conflict among distinct user groups and between recreation activities.
 3. Establish appropriate data management programs for monitoring human activities at Whiskeytown.

Progress: The project will be completed in three phases. Phase I, completed in the summer of 1984, was a pilot study to pretest a set of questions and to determine sampling alternatives for the project. Results were used to guide questionnaire and sample design development for Phase II.

Phase II, the data collection period, took place during the summer of 1985. Approximately 3200 visitors were contacted at 16 sites at Whiskeytown Lake. Visitors were asked to complete a mailback questionnaire which asked for a variety of information including length of stay, activities, reasons for visiting Whiskeytown, perceptions of crowding and social conflict, participation in interpretive activities, and demographic data. Close to 75 percent of the questionnaires were completed and returned.

Phase III, the analysis of data, was begun in 1986. Thus far, three reports have been completed. The first is a bibliography of water-based recreation research. This document will serve as a reference for the managers at Whiskeytown by placing the present study in the context of past research. The document likewise will serve as a guide to understand

relevant research or management reports on other issues associated with the reservoir.

The second report describes the sixteen research sites at Whiskeytown where interviewing took place. These sites are described in terms of their social, biological, and managerial characteristics. Referred to as recreation places, these places become the habitats where recreation behavior takes place and was observed.

The third report is a descriptive overview of the people and the recreation participation patterns at Whiskeytown. Discussions of population age, location of residence, time spent at Whiskeytown, and activities participated in comprise the report. Subsequent reports will focus upon an analytical description of similarities and differences among people visiting sites, their participation, social conflicts, and attitudes towards management issues.

Analysis of data will continue into 1987.

THE PACIFIC NORTHWEST OUTDOOR RECREATION STUDY

Principal Investigators: Donald R. Field
NPS Cooperative Park Studies Unit
Oregon State University

Perry J. Brown
Resource Recreation
Oregon State University

Research Assistant: Denver Hospodarsky
Resource Recreation Management
Oregon State University

The 1986-87 Pacific Northwest Outdoor Recreation Study is a coordinated regional approach to gathering recreation demand data central to the SCORP process. A first for the region, the study will provide current recreation use data and future recreation demand projections not only for the states of Oregon, Washington, and Idaho but also for the Northwest as a geographic region. Close coordination among participating state and federal agencies during questionnaire and sample design has ensured the compatibility and comprehensiveness of data for regional modeling of recreation demand.

The majority of visitors to many recreation areas in the Northwest are from regionally contiguous points-of-origin. Thus, regional recreation demand data has enhanced potential for state and federal management planning functions. The greatest potential uses of regional recreation data involve the identification of recreation activity and regional travel patterns and trends. This has application for:

- 1) determining the interrelatedness of recreation sites as these sites represent multiple destinations in an individual's overall recreation itinerary. Gaps or redundancies in visitor services at various sites may become evident when the overall visitor experience is considered within the context of the recreation system;
- 2) determining the complimentariness of sites as a regional recreation system allows for the selective promotion of lesser-used areas, thereby directing use away from more popular areas in the same region;
- 3) determining if differences exist in recreation patterns among states or for regions within a state, and whether these differences are reflected in a visitation to certain recreation areas i.e., does a site have a local or more regional clientele?

- 4) determining of certain "types" of people visit certain types of recreation areas e.g., areas managed for historical versus natural features;
- 5) providing baseline data for the projection of future recreation demand. From this baseline, the effect of demographic and leisure trends such as those toward shorter vacations and regional travel closer to home can be assessed; and
- 6) providing data for anticipating and ameliorating the impacts on site visitation from state and regional tourism promotions that are increasingly common in the Northwest. Prior knowledge of the site effects of promotional campaigns allows recreation management agencies the opportunity to assume a collaborative role with economic development organizations in planning promotions that minimally conflict with or enhance resource management objectives.

Currently, the Department of Resource Recreation Management staff are interviewing 3,000 Oregon residents about their participation in outdoor recreation. Data collection began in June 1986 and will continue until June 1987.

A VISITOR PULSE AT FT. VANCOUVER NATIONAL
HISTORIC PARK AND FT. CLATSOP NATIONAL MEMORIAL

Principal Investigator: Donald R. Field
NPS Cooperative Park Studies Unit
Oregon State University

Research Associate: Marty Lee
Resource Recreation Management
Oregon State University

Visitation to National Park Service Areas, while on the increase, fluctuates from year to year, season to season, and during the week. Visitation to parks, in other words, occurs in "cycles." Therefore, periodic monitoring of visitors provides managers with an update of who is visiting a site and the nature of their visit for a given time frame.

The sociological pulse at Ft. Vancouver National Historic Park and Ft. Clatsop National Memorial was intended to provide a current picture of visitation to the respective areas. By tapping into the summer cycle for one August weekend, we provided the park superintendent and his staff with an assessment of 1) who is visiting the park, 2) characteristics of the visiting public, 3) a description of their visit, 4) an evaluation of the services provided by the park, and 5) limited information about park visitors' stay in the immediate area.

Draft reports were completed in November 1986 and circulated to the respective parks for critique. A final report was completed in December.

NATIONAL PARKS AND A REGIONAL RESOURCE SYSTEM

Principal Investigator: Donald R. Field
NPS Cooperative Park Studies Unit
Oregon State University

The impacts of rural resource development activities such as forestry, mining, agriculture, and tourism upon parks, can best be examined in terms of a regional resource system. Park ecosystems are interdependent with the adjacent region and preservation of park resources hinge upon the knowledge of primary resource production activities occurring within the region and development of regional resource management plan. As natural resources become more scarce, complimentary and supportive resource management activities ensuring the preservation and conservation of the diversity of natural resources within the region will be required. The project currently is concerned with the formulation of a conceptual framework for examining national parks in the context of a regional resource system.

During the past year a bibliography entitled Rural Communities and Natural Resources (CPSU/OSU 86-5) was completed.

PROJECT SUMMARIES:
APPLICATION OF SCIENCE

MANAGING PEOPLE IN PARKS AND FOREST WORKSHOP

Workshop Coordinator: Donald R. Field
Cooperative Park Studies Unit
Oregon State University

Dates: Offered Annually

Objectives: To illustrate the use of social science theory and research for public land managers of parks and forests in the decision-making process. The discussion of contemporary issues in recreation will provide the foundation for participants to look ahead and plan for the decade of the 90's. Data management systems reviewed include those available for microcomputers. Instruction will be by means of lectures, small group assignments, and panel discussion by experts in social science research and senior managers from federal and state land management agencies. The course will be of interest to park rangers, forest rangers, BLM district managers, Corps of Engineers recreation managers, and others who are responsible for recreation management or involved with preparing or interpreting social science data for planning purposes.

PEOPLE, HUMAN BEHAVIOR AND WATER-BASED RECREATION:
A WORKING BIBLIOGRAPHY

Compilers:

Kristen Martinson
Dept. of Resource Recreation
Management
Oregon State University

Don Field
Cooperative Park Studies Unit
Oregon State University

Purpose: The bibliography provides a guide to the behavioral research on water-based recreation by cataloging aspects of the theme which are relevant to resource managers and social scientists. The references included cover user characteristics and behavior, resource settings, social issues, management, and economic and noneconomic analysis of water-based recreation.

This working bibliography will be expanded and updated, and we encourage contributions, citations, and suggestions.

COMMUNITY AND NATURAL RESOURCES DEVELOPMENT:
A WORKING BIBLIOGRAPHY

Compilers:

Donald R. Field
Cooperative Park Studies Unit
Oregon State University

Denver Hospodarsky
Resource Recreation Management
Oregon State University

Richard Converse
NPS/CPSU
University of Washington

Purpose: The bibliography provides a synopsis of research studies conducted on resource-dependent communities. The intent of the bibliography is to include examples where a change in some aspect of the biological system generated a change in the social system and vice versa where a change in the social system altered the biological system.

Articles and reports are organized under four headings: 1) social organization, 2) distinct population, 3) technology, and 4) environment.

MICROCOMPUTER APPLICATIONS:
AN INTRODUCTORY WORKSHOP FOR RESOURCE MANAGERS

Workshop Coordinators: Marty Lee
Dept. of Resource Recreation
Management
Oregon State University

Ed Starkey
Cooperative Park Studies Unit
Oregon State University

Date: June 17-18, 1986

Objectives: To familiarize resource managers with the general operation of microcomputers.

Instructional format combined lectures and discussion with ample opportunity for "hands-on" experience. Participants were exposed to a variety of commercially available programs with examples and exercises emphasizing natural resource applications. Sessions included an introduction to microcomputer hardware and software (languages, operating systems), financial analysis, managing data, word processing, graphic display of data, and software currently being used in natural resource management. Fifteen people from various federal, state, and private agencies attended the workshop.

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